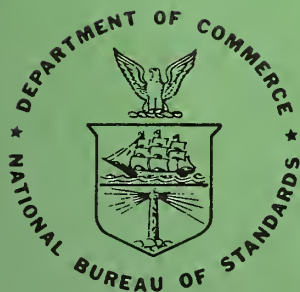# NBS TECHNICAL NOTE

433

Input/Output Packages for the
Systems 360 Assembly Language Processor

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D. C. 20234.
[2] Located at Boulder, Colorado 80302.
[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

NBS TECHNICAL NOTE 433

Input/Output Packages for the Systems 360 Assembly Language Processor

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Contents

INPUT/OUTPUT PACKAGES FOR THE SYSTEMS 360
ASSEMBLY LANGUAGE PROCESSOR

P. A. D. deMaine

Three input-output (I/O) software pack-
ages for use with the Assembly Language Pro-
cessor (ALP) of the Systems 360 are described.
They are for card read, on-line-print and
card punch operations. A single pseudo-opera-
tion statement, which contains all required
formats and addresses, suffices for the execu-
tion of each input-output package. Printed
error and guide messages aid in program
debugging. In addition to the conventional
formats (A, I, F and E), Systems 360 column
binary (X) and hexadecimal (J and B) are per-
mitted. With a single pseudo-operation these
I/O packages can handle up to eight individual
items or arrays of any length in a single or
mixed format.

**Key words: Assembly language; card punch; card read;
input/output; on-line print; system 360.**

1.   Introduction

As the first step in coding the SOLID System [1] for the
Systems 360, some additions to the Assembly Language Processor
(APL)[1] had to be made. At the time of writing there is still
a lack of input/output capability for handling any but the most
primitive formats (Systems 360 column binary and core dumps).
The I/O packages which are described here have been coded in
compiler. The packages themselves have been incorporated into
the Systems [2], which is now being implemented for evaluation on
the IBM 360/40 (with 262K memory, two 2311 disk drives and eight
2402 tape drives) at the Washington Data Processing Center,
Department of Agriculture, Independence Avenue, Washington, D. C.

The author's prior experience with monitors for medium mach-
ines[2] and the PORTHEUS and IBSYS executive systems have contrib-

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[1]See IBM manuals A22-6821-2 and A22-6810-7

[2]For example, the IBM 620/40K with 1316 disk drive at the Univer-
sity of California, Santa Barbara, and the IBM 620/60K at the
University of Mississippi, Oxford.

uted[1] much to the design of the new I/O packages. Basic to the design is the concept that I/O should be easy to use, without sacrificing the versatility achieved in some large systems (e.g., with FORTRAN IV). In this regard the elegant simplicity of the I/O for earlier versions of FORTRAN for smaller machines, notably the FORTRAN WITHOUT FORMAT (IBM 4-1-61), and especially for FAP in PORTHEUS are particularly attractive. The Systems 360 assembly language, with its instructions for selectively opening (OPEN) and closing (CLOSE) peripheral devices and its dual logic[2] appears to be ideally suited for designing general-purpose I/O packages that can be used in any of the coding levels of the SOLID System.

The purpose of this report is to describe the essential features of the new Systems 360 I/O packages. The individual packages are described in detail in other reports[3].

2. Description of New I/O Packages

Each of the three new I/O packages, read cards (REIDY), punch cards (PUNXH), and print (PR1NT), contains a single macro-subroutine and at least one calling macro, which generates the calling procedure for the subroutine at assembly time. The prototype statements for each macro <u>contain all the information</u> needed to execute the I/O operation. The prototype statement for each macro-subroutine defines the registers which are to be used to establish addressability, i.e., USING, and to branch, i.e., the return vector. See Table I. Storage (in bytes) required for the assembled components are given in the table. At assembly time the instruction SUBMP correctly positions each subroutine. Calling procedures, generated by the single pseudo-operations are assembled in the main body of the object program; formats (&F) and addresses (&FROM, &TO, &W1, &W2, ..., &W8) are defined, and the USING and branch registers &UR and &RR are discussed in the following paragraphs.

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[1] PORTHEUS, the executive system for the IBM 7094/1401 at the University of Illinois, is itself a modification of the University of Michigan's MAD System, and the IBSYS is the executive system for the IBM 7094/7040 at the Western Data Processing Center, University of California, Los Angeles.

[2] These are identified at (1) storage-to-storage instructions in which only base registers appear and (2) the normal instruction set in which registers are used for indexing and/or arithmetic.

[3] All detailed reports on the SOLID System are published as National Bureau of STnadards Technical Notes. Listing of the packages can be obtained on request.

TABLE I. Prototype statements for the calling procedure macros and macro-subroutines for the indicated I/O packages.

I/O Package	Calling Procedure Macro Prototype Statement for I/O Pseudo-Operstions	Stor-age	Macro-Subroutine	Stor-age
PRINT	&J PRINT &F, &FROM,&TO	12.6	SPRINT PRINT, &UR, &RR	1406
PUNCH (Cards)	&J PUNXH &F, &FROM, &TO	356*	SPUNXH PUNCH, &UR, &RR	1400
	&J REIDI &F, &W1	164		
	&J REID2 &F, &W1, &W2	170		
	&J REID3 &F, &W1, &W2, &W3	176		
READ	&J REID4 &F, &W1, &W2, ..., &W4	182	SREID READC, &UR, &RR	2400
(Cards)	&J REID5 &F, &W1, &W2,...,&W5	188		
	&J REID6 &F, &W1, &W2,...,&W6	194		
	&J REID7 &F, &W1, &W2,...,&W7	200		
	&J REID8 &F, &W1, &W2,...,&W8	206		

* Special X-format version requiring no SPUNXH subroutine.

Two other macros, which have no arguments, play an important part: (1) RESERVE, which is inserted immediately after the START instruction of the source program, generates instructions for opening peripheral devices and defines all constants, counters, words, DCB or format statements[1], arrays and registers used in the SOLID System. If the new I/O packages are to be used separately from the SOLID System some instructions in RESERVE can be omitted. (2) SUBMP, which precedes the END instruction in the source program, generates instructions for closing peripheral devices, establishes addressability (via the USING statement), allocates the branch register and correctly positions each subroutine. The branch, i.e., the return vector, and USING registers for each subroutine are changed by replacing a single instruction (the prototype statement for the macro-subroutine) in the SUBMP macro. In our programs either of two registers (8 or 9) may be used to establish addressability in the subroutine. Any one of five registers (1, 4, 6, 7, and 8 or 9) may be assigned for

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[1]Two DCB's are defined: The first (for printing) handles 133 bytes, and the second (for punching or reading) handles 80 bytes.

branching back from the subroutine to the calling procedure.

The single statement (pseudo-operation) which assembles the calling procedure for the designated subroutine can be inserted anywhere in the source program between the RESERVE and SUBMP pseudo-operations. The storage required for each calling procedure is given in Table I.

INPUT/OUTPUT PACKAGES.....

I/O PSEUDO-OPERATIONS

The pseudo-operations for the three I/O packages are as follows:

PRINT	F, FROM, TO	... On-line print
PUNXH	F, FROM, TO	... Punch card(s)
REIDY	F, W1, W2, ..., ..., WY	... Read cards(s)

In the REIDY pseudo-operation, Y is a numeral (1 to 8) which corresponds to the number of variables (W1, W2, ...) entered.

Addressing: Addresses of variables appearing in the pseudo-operations (FROM, TO, W1, W2, ¶3, ..., W8) can have any form, permitted for the Systems 360 assembly language, except D1(R1, B1) Some examples of permitted addresses are Z, Z+1, Z(IR), O(IR), 1000, 1000(IR), IR, = C'ADDRESS', and *+r, with IR an index register.

PRINT F,0,9 will list the contents of general registers 0 to 9. Except for the requirement that FROM must not be great-er than TO[1], there is no restriction on the addresses which can appear in the PRINT and PUNXH pseudo-operations. If protected locations in low and high core areas are addressed in a REIDY pseudo-operation, the ADDRESSING ERROR message is given and the I/O is terminated.

Formats: The code F, which appears in all pseudo-operations, is used to compute the individual formats for each string or word handled by the I/O packages. The seven individual formats are Hollerith (A), Systems 360 Column Binary ($\overline{X}$), Strings (J) and four-byte words (B) of hexadecimal digits, and the conventional decimal formats (I, E and F).

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[1]
In case of this error the I/O operation is terminated with the message ADDRESSING ERROR, and control returns to the calling procedure for reassignment to the next instruction.

4

The following definitions are needed to understand the computational rules. A field of length N contains N printed or punched EBCDIC codes (the System 360 field data doces of eight bits). In the PUNXH and PRINT pseudo-operations B, I, F, E, or mixed formats[1] yield fields with a fixed length of 14 EBCDIC codes, which are separated either by two blanks (PRINT) or by a blank and a 0-8-2 punch (PUNXH). With the REIDY pseudo-operation and the same formats a single card can have up to 20 fields with a maximum total length of 80 columns. In this case a single 0-8-2 punch terminates each field. However, only for single arrays (Y + 1) will the computer read more than Y fields per card.

With an A, X, or J format and one variable the single field can have any length. Strings of Hollerith (A) or hexadecimal (J) information are terminated with two 0-8-2 punches. Each field of Systems 360 column binary (X format) is prefaced with a single card which contains the total number of bytes which are to be read (REIDY) or punched (PUNXH).

A variable designates either an array or a single item of I/O information. The number of variables (NOV) in the REIDY pseudo-operation equals the integer Y, which is less than nine. In the PUNXH and PRINT the number of variables equals the number of individual formats in the format code F. In this case the maximum value for NOV is five (PUNXH) or eight (PRINT).

The format code F in each I/O pseudo-operation consists of a single string of from one to five (PUNXH) or eight (PRINT and REIDY) format symbols (i.e., A, X, J, B, I, F and E). Mixed strings like AEIFBB can contain the column binary (X) and hexadecimal string (J) formats but the reader is advised to avoid their use. Word alignments are particularly important and, in the general case, difficult to keep straight. In the REIDY pseudo-operation an asterisk at the beginning of the format code F means that the information will be read from more than one card.

X format was designed for the esay manipulation of Systems 360 column binary information. The pseudo-operation PUNXH X, FROM,TO means that (TO - FROM + 1) bytes of information, located in the computer in the area FROM to TO, are to be punched in column binary, i.e., 80 bytes/card. A single card containing the column binary number (TO - FROM + 1) prefaces the card deck. The pseudo-operation REID1 *X,BEGIN means that column binary is to be loaded starting at the byte with address BEGIN. The first card, of the input deck contains the number of bytes (column binary) to be read.

_____

[1] A typical mixed format is obtained by entering ABFIEIII for the code F; this means that eight fields are to have formats A, B, F, I, E, I, I and I, respectively.

3. Computer Procedures

One feature of the new I/O package is a system of error messages and corrective procedures that greatly increases its usefulness. In this section the computational procedures are first described and then some actual examples of formats and I/O messages are given.

At assembly time the Pseudo-operations, which appear in the source program, are used to construct the calling procedures for the I/O subroutines. The flow-chart for a typical calling procedure is given in Figure I. After saving all index registers, the format (F) and number of variables (Y) are transferred to storage areas FORMAT and NOV. In the next step certain information from the calling procedure (see examples) is stores in a temporary array. This information will be used in the subroutine to construct the printed guide statement. Next the absolute address for each variable (W1, W2, --- WY) is obtained by the load address operation and stored in the array ADDRESS. The location of the pseudo-operation in the source program is stored in register 5, after which the branch-and-link procedure is executed. The return vector (branch register) contains the address of the last statement in the calling procedure, which resets all index registers to their initial values. For the PUNXH and PRINT I/O packages, NOV (number of variables) is calculated in the subroutines.

In all subroutines the number of format symbols in FORMAT are counted in NF. In the REIDY subroutine the next step is to compare the number of variables (NOV) and the number of formats (NF). If NOV = NF $\neq$ 1, either arrays (designated by an asterisk in the left-hand byte of FORMAT) or NOV single items are to be read. If NOV = NF = 1 and a single array is indicated (see previous discussion of Formats on page   ), NOV is set equal to 20 and the format symbol (in the left byte of FORMAT) is propagated in the first 20 positions of array FORMAT. If NOV $\neq$ NF, NOV is set equal to NF and the first symbol in FORMAT is propagated for all fields. Some results of these computations are illustrated below:

1. Each of the pseudo-operations REID2 I,W1,W2; REID2 IBE, W1,W2 and REID2 II,W1,W2 will read two fields with decimal integer formats from a single card.

2. REID2 *I,W1,W2; REID2 *IAE,W1,W2; or REID2 *II,W1,W2 will read two fields per card with decimal integer format until a double 0-8-2 punch, which signified the end of the arrays, is encountered.

3. REID1 *I,W1 will read up to 20 decimal integer fields per card until the termination code (a double 0-8-2 punch) is encountered.
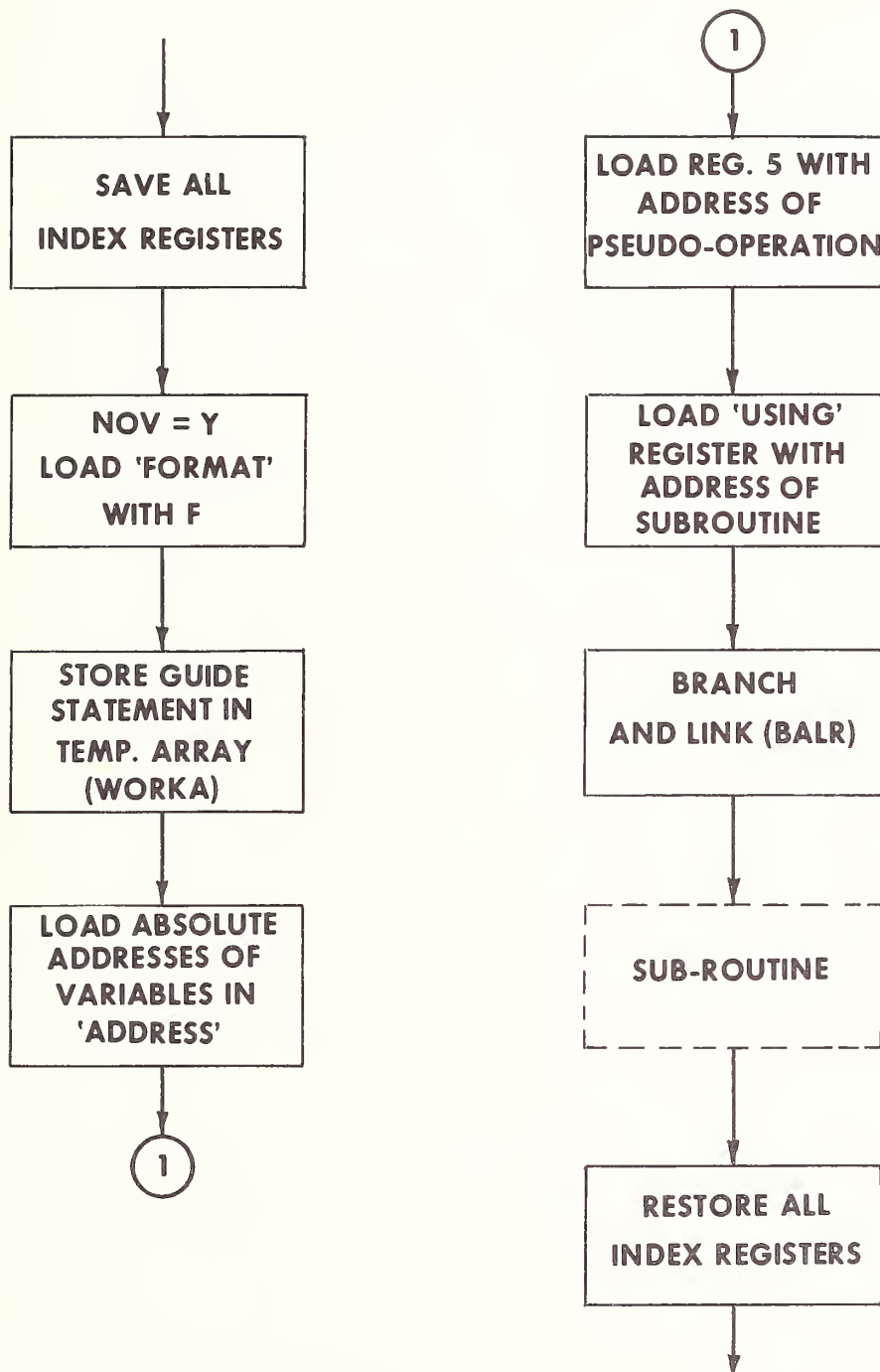
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FIGURE 1. Flow Chart for the CALLING PROCEDURE of the Card-Read I/O Package:
Pseudo-Operation   REIDY F, W1, W2, W3, ..., WY

4. REID1 *I$\overline{X}$,W1, with $\overline{X}$ equal to any format symbol, will read one decimal integer per card until the termination code is encountered.

In the PUNXH and PR1NT subroutines, after counting the format symbols in FORMAT with NF, the two addresses (FROM and TO) are compared. If FROM is greater than TO, the guide and error statements are assembled and printed (see examples), then control returns to the calling procedure for reassignment. Otherwise, the number of variables (NOV) is set equal to minimum [N, (1 + (TO − FROM)/4][1], with N = 5 (PUNXH) or 8 (PR1NT), and NOV is compared with NF. If NF equals NOV, all fields have been assigned formats. Otherwise NF is set equal to NOV and the first format symbol is propagated in the first five (PUNXH) or eight (PR1NT) bytes of FORMAT. The consequences of these actions are illustrated next:

1. PR1NT B,FROM,FROM+28; PR1NT BIA,FROMFROM+28 will print a single line with eight fields of length 14. Each field will contain eight hexadecimal digits, right-adjusted.

2. PR1NT IBIEFEIB,FROM,FROM+60 will print two lines, each with eight fields of length 14 and separated by two blanks. The eight data fields of numbers, beginning on the left, will be in I,B,I,E,F,E,I,and B formats. PUNXH would yield similar results for cards with 80 columns. If single A or J formats are used in either the PR1NT or PUNXH pseudo-operations the field boundaries are ignored and a single string of Hollerith (A) or hexadicimal (J) characters are printed (132 characters per line) or punched (80 characters per card).

In the next step the guide statement is constructed and printed. This statement contains the hexadecimal location of the pseudo-operation, the address(es) in the pseudo-operation (FROM, TO, etc.), and the format which is to be used for each field. With the PUNXH pseudo-operation another guide statement, with an asterisk in column one, is also punched. With the REIDY pseudo-operation the first 16 characters on the first data-card are printed immediately after the guide-statement. Also, in REIDY, any card with an asterisk in column one is treated as a normal comment card and is printed. The minor restriction this imposes on fields with Hollerith (A) format is a small price to pay for the easy method of clearly labeling input information.

No attempt will be made here to describe details of the three I/O packages. Single strings of Hollerith (A) or hexadecimal (J) information create no special problems.[2]

---

[1]A four-byte word is assumed

[2]All blanks are eliminated from hexadecimal input

The results achieved with these packages are summarized for B,I,F,E and mixed formats:

1. <u>Input (REIDY)</u> (B,I,F and E Formats)

a. The actual information stored for each field occupies four bytes. Floating-point numbers are always stored in their normalized forms. Hexadecimal and decimal integer numbers are right-adjusted.

b. Blanks and leading zeros in fields with B,I,E and F formats are eliminated. If the number is too large to be represented in 32 binary bits, truncation occurs on the right. Examples are as follows:

Hexadecimal: 00 12 375EF FE1 is stored as 12375EFF.
Decimal Integer: -01 23456789998 is stored as -12345678999.

The truncation rules for F and E formats are determined by the number of significant decimal digits before and after the decimal point and the magnitude of the exponent. In general, numbers between $\pm 10^{-12}$ and $\pm 10^{12}$ can, of course, be entered via the hexadecimal (B) format.

c. With E or F format 1, 1.0, 0.001E+3, 1000E-02 etc. is stored as 0.1 E+01.

2. <u>Output (PUNXH and PRINT)</u> (B,I,F and E Formats)

There is no special problem associated with a field which has B or I formats. With E and F formats the following rules apply:

a. All numbers are printed or punched in their normalized forms.

b. If the number requested has an exponent greater than 11 or less than -11, the hexadecimal form is printed or punched.

c. Blanks in the fractional part of a printed or punched floating-point number indicate that significant bits of information were lost during conversion of the binary representation to its decimal form. That is 0.11 E+12 means that only the first two significant numbers are reliable, 0.1100000E+12 means that the first seven significant numbers are reliable. Some examples of the various forms of I/0 formats and messages are given in the next section.

4. Examples

Throughout this section the $ means an 0-8-2 punch. In the REIDY pseudo-operation a single 0-8-2 punch terminates each field and a double 0-8-2 punch at the end of the last field terminates arrays. Each line of data is on a single card.

I. The statement:

    REID2 I, NV, JI

(1) read a single card:

    2      $0 $ (two fields of length 6)

(2) and printed:

****

READ IN AFTER STATEMENT 00009E82. INFORMATION FOR NV, JI.
FORMAT=II
THE FIRST 16 BYTES READ WERE: 2   0   .8 BYTES STORED.

****

(Both NV and JI are stored as decimal integers.) The location of the REIDY operation in the program is 00009E82.

II. The statement:

    REID2 IE,SOS(3),LSX(3)

(1) read a single card:

    0      $.12$ (two fields, lengths 6 and 3)

(2) and printed:

****

READ IN AFTER STATEMENT 00009F34. INFORMATION FOR SOS(3),LSK(3).
FORMAT=IE
THE FIRST L§ BYTES READ WERE: 0   .12   .8 BYTES STORES.

****

(sos(3) contains a decimal integer; and LSX(3) contains a normalized floating point number.)

III.   The statement:

        REID1*E,O(BRYY)

read 561 floating and fixed point numbers and stored them as
normalized floating point in the indicated array, beginning with
O(BRYY)[1].   The 561 numbers were punched nine to a card, with
fields of length 7.   A double 0-8-2 punch terminated the I/O
operation.   The guide statement printed was:

****

READ IN AFTER STATEMENT 0000A00E.   INFORMATION FOR O(BRYY) ARRAYS.
FORMAT=EEEEEEEE
THE FIRST 16 BYTES READ WERE: 90.0   88.5 86.2244 BYTES STORED.

****

IV.   The statement:

        PRINT I,LEXMODE,LEXCON

printed:

****

AFTER STATEMENT 00009BCA.   FIRST=LEXMODE; LAST=LEXCON; FORMAT=I
ADDRESSING ERROR

****

because the address of LEXMODE was larger than LEXCON.

V.   The statement:

        PRINT BBBBE,PCORDS(2),PCORDS(3)

printed:

****

AFTER STATEMENT 000085B0.   FIRST=PCORDS(2); LAST=PCORDS(3);
FORMAT=BBBBE
01502800   00000000   00000000   00000000   +0.3999996E-02

****

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[1]BRYY is an index register.

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